PM_{10}, VOLATILE ORGANIC COMPOUND, AND METEOROLOGICAL PARAMETER MONITORING PLAN

Sims Metal
Paulina Facility

TRINITY CONSULTANTS
1801 S Meyers Rd, Ste 350
Oakbrook Terrace, Illinois
60181

June 2022

Project 214501.0047

Trinity Consultants

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This monitoring plan (MP)[1] outlines the continuous particulate matter less than 10 microns in size (PM_{10}) and meteorological monitoring, and the periodic canister sampling (as described in detail below) of volatile organic compounds (VOCs), that will be performed around the Metal Management Midwest, Inc., d/b/a Sims Metal (Sims) metal recycling Facility located at 2500 South Paulina Street in Chicago, Cook County, Illinois (the Facility). This MP addresses the continuous PM_{10} monitoring and periodic VOC canister sampling and describes additional analysis as required by the 114 request. In addition, the plan describes how samples will be collected to directly measure metal hazardous air pollutants (HAPs)[2], VOC and other specified compounds, and how the data will be utilized. This MP will be implemented and overseen by the Sims Safety, Health, Environment and Community (SHEC) Director. During the monitoring period, the Sims personnel will communicate any alert conditions or near alert conditions to the SHEC Director so that appropriate corrective actions and response measures can be implemented.

1.1 Background

This MP outlines the PM_{10}, VOC, and meteorological monitoring that will be conducted pursuant to a U.S. Environmental Protection Agency (EPA) Section 114 (a) information request. This MP also describes the equipment to be installed, the locations of the continuous PM_{10} monitors, VOC canister samplers, and meteorological tower, and information concerning the operation, maintenance, and calibration of the PM_{10} monitors, VOC sampling systems, and meteorological sensors.

1.2 Facility Description

The Facility is a metal recycling operation that among other things purchases end-of-life vehicles (ELV), appliances and other light gauge steel items (Light Iron; with ELV Feedstock Material), processes the Feedstock Material by means of a metal shredder (the Shredder) and other equipment, and ships recyclable ferrous and non-ferrous metal products. The Facility occupies approximately 10 acres of land in Chicago's Lower West Side, North of the Sanitary Ship Canal.

Various suppliers provide feedstock material to the Facility, including "peddlers," typically in a pickup truck, ELV suppliers, typically using flatbed trucks, and commercial/industrial suppliers typically by means of Sims or contract hauler trucks with semi-trailers, dump-trailers or other trailer-types. Suppliers entering the Facility must first proceed to a truck scale to be weighed. Suppliers are then directed to the appropriate unloading area where the loads are inspected for prohibited or otherwise unauthorized materials. Prohibited materials discovered during inspections are rejected.

[1] This monitoring plan is required per paragraph 2 of the April 21, 2022 U. S. EPA Section 114(a) request to provide information pursuant to the Clean Air Act ('114 request').

[2] Per the 114 request, certain metal Hazardous Air Pollutants (Metal HAPs) need to be evaluated at a minimum frequency of 1-in-3-day schedule. The Metal HAPs are antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium.

The shredder produces a ferrous product and a nonferrous metal intermediate product (Nonferrous Material). The nonferrous material is loaded into a truck, transported to the nearby Metal Recovery Plant (MRP) location, and temporarily stockpiled. A front-end loader places the Nonferrous Material into the MRP batch feeder, where it is processed to separate various nonferrous metal products. The non-metallic residue (ASR) is stored in a bin and then transported off-site for disposal. Ferrous and nonferrous metal products produced from feedstock materials are shipped to mills and smelters for remelting purposes.

The latitude and longitude coordinates for the Sims Facility are:

Latitude: 41° 50’47.43” North
Longitude: -87° 40’13.29” West

Figure 1.1 presents a Google Earth image presenting the location of the Sims Facility. An enlarged view of the Sims Facility is presented in Figure 1.2.

Figure 1.1 Google Earth Image Showing Location of the Sims Paulina Street Facility

Figure 1.2 Enlarged View of Sims Facility

2.0 MONITORING EQUIPMENT AND SAMPLING LOCATIONS

Five (5) perimeter near-reference method continuous PM_{10} air monitors (Met One E-Samplers) will be deployed around the Facility. The perimeter air monitoring stations will monitor PM_{10} continuously, 24-hours per day, seven days per week. In addition to the five PM_{10} monitoring stations, a meteorological station will be installed at the Facility and operated to continuously monitor meteorological conditions.

Three of the PM_{10} monitoring stations with locations nearest to residential areas will be utilized to also collect 24-hour samples for laboratory analysis. VOC sampling systems will also be installed at these locations.

2.1 PM_{10} Sampling Equipment

Continuous PM_{10} monitoring will be conducted at five locations using near-reference monitors. At three locations, the PM_{10} samplers will be configured to collect filter-based samples in accordance with EPA's 1-in-3-day sampling schedule.

2.1.1 Near-Reference PM_{10} Monitors

Continuous PM_{10} monitoring will be conducted at the Facility utilizing Met One Instruments, Inc. E-Sampler compact monitoring stations. The E-Sampler is a dual technology instrument that combines the unequaled real-time measurement of light scatter with the accuracy standard of filter methods. The simple filter loading process is a seamless blending of both technologies. Filters can be extracted and replaced in less than one minute, and the filter medium can be selected based on laboratory analysis. Particulate loading on the filter does not reduce performance due to the Met One actual flow control protocol. Ambient temperature and pressure are measured, and actual flow is calculated and controlled by the E-Sampler microprocessor independent of filter loading change.

The E-Sampler is a near-reference monitor which provides real-time particulate measurement through near-forward light scattering. An internal rotary vane pump draws air at 2 liters per minute (LPM) into the sensing chamber, where it passes through visible laser light. Particles in the air scatter light in proportion to the particle load in the air. The scattered light is collected by precise glass optics and focused on a PIN diode. Rugged state-of-the-art electronics measure the intensity of the focused light and output a signal to the CPU. The output is linear to concentrations greater than 65,000 micrograms per cubic meter ($\mu g/m^3$).

The sharp cut cyclone is a precision engineered component fitted to the dust meter inlet that physically selects particles 10 microns in diameter and below. This ensures precise measurement of only the PM_{10} size fraction. The inlet is fitted with a heater that is used to remove moisture from the incoming sample. Moisture can reduce the accuracy of optical measurement, so for best results the inlet heater is activated in the event of high humidity.

Each E-Sampler will be equipped with a Campbell Scientific CR1000X data logger to collect and store PM_{10} and flow information as well as other important instrument status readings. All PM_{10} data will be collected and stored in the units of μg/m^3, which is consistent with units for the 24-hour National Ambient Air Quality Standards (NAAQS) for PM_{10}. A specification sheet for the E-Sampler is presented in Appendix A.

2.1.2 Filter-Based Sampling

At three locations, the PM_{10} E-sampler will be operated utilizing the second channel of the sampler specifically designed to accept 47-mm filters. The sampler accommodates a single quartz fiber 47-mm diameter filter and requires manual operation. There is no timer feature to start and stop the sample, therefore field technicians will exchange filters on a routine basis during daylight operating hours. Exposed 47-mm quartz fiber samples will be retrieved, placed in cold storage, and shipped to the laboratory for post-weighing and further metal HAP analysis. In the E-Samper, a sample stream passes through filter cassettes containing a 47 mm diameter sample filter. A mass flow controller downstream of the filter controls the flow rate at a constant volumetric level. The sampler is configured to collect samples continuously, and field personnel will install and retrieve sample filters at a specific time each sample day to provide for a 24-hour sample every three days in accordance with the schedule adopted by EPA.

2.2 Volatile Organic Compound Monitoring Equipment

Speciated VOC measurements will be collected using six-liter SUMMA® canisters connected to canister samplers and analyzed for specific compounds using EPA Compendium Method TO-15A. Each sampler will be outfitted with a timer that enables automatic start/stop operation so that canisters can be exchanged prior to a sampling event. An adjustable flow controller will be used to control the sample flow rate into the canister for a 24-hour integrated sample with some negative pressure remaining in the canister at the end of the period. Canister samples will be collected intermittently, according to EPA's 1-in-3-day monitoring schedule.

2.3 Meteorological Monitoring Equipment

Sims will install a 10-meter tower to continuously measure the following parameters at the site:

- Wind speed at 10 meters,
- Wind direction at 10 meters,
- Temperature at 10 meters,
- Relative humidity at 10 meters, and
- Precipitation (near ground-level).

A brief description of each meteorological sensor is presented below. Specification sheets for each meteorological sensor is presented in Appendix A.

2.3.1 Wind Speed and Wind Direction

The R.M. Young Model 05305 Wind Monitor AQ, to be used at the 10-meter level, is made of UV-stabilized plastic with stainless steel and anodized aluminum fittings. Precision grade, stainless steel ball bearings are used. Transient protection and cable terminations are in a convenient junction box.

The wind speed sensor is a four-blade helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. Slip rings and brushes are eliminated for increased reliability. The starting threshold is 0.4 m/s.

The wind direction sensor is a rugged yet lightweight vane with a sufficiently low aspect ratio to assure good fidelity in fluctuating wind conditions. Vane angle is sensed by a precision potentiometer housed in a sealed chamber. With a known excitation voltage applied to the potentiometer, the output voltage is directly proportional to vane angle. A mounting orientation ring assures correct alignment of the wind direction reference when the instrument is removed for maintenance. The vane starting threshold is 0.5 m/s at 10 degrees displacement.

2.3.2 Relative Humidity and Temperature

The Campbell Scientific Hygrovue relative humidity (RH)/temperature probe is designed for rugged, accurate air long-term, unattended applications. It includes a proprietary coating on the RH element that increases the life of the element and protects it from dirt, dust, salt, or other contaminants. The relative humidity sensor has an accuracy of ±1.8% from 0 to 80% RH and± 3.0% RH, from 90 to 100% RH.

2.3.3 Precipitation

For precipitation measurements, a Texas Electronic model TE525 tipping bucket rain gage is proposed. The precipitation is funneled into a bucket mechanism that tips when filled to a calibrated level. A magnet attached to the tipping mechanism actuates a switch as the bucket tips. The momentary switch closure is counted by the pulse-counting circuitry of a Campbell Scientific datalogger. The accuracy of the gauge is 1.0% up to 2 inches per hour.

2.3.4 10-Meter Tower

All proposed meteorological sensors will be secured to a Campbell Scientific Model UT30 10-meter guyed aluminum tower. The UT30 includes a mounting base secured in concrete. Lightning protection will be mounted to the tower. The tower tilts down to ground level which eliminates the need to climb the tower for servicing.

2.3.5 Meteorological Data Acquisition System

The meteorological data will be continuously recorded on a Campbell Scientific, Inc. CR1000X data acquisition system. The meteorological tower will be located adjacent to a continuous PM_{10} monitor and will utilize the CR1000X data acquisition system at the monitoring station.

2.4 Placement of the Ambient PM_{10} Monitors

Monitoring site selection guidance presented in 40 CFR Part 58 Appendices A and E was considered when selecting the placement of the PM_{10} monitors. The proposed sites were selected based on suitability of terrain and distance from obstructions to ensure that representative data are collected. Accessibility to each site was also an important consideration in choosing the placement of the monitors.

Five monitoring sites were identified (AQ1, AQ2, AQ3, AQ4, and AQ5) and are presented in Figure 2.1 below. All five sites will be equipped with near-reference E-Sampler PM_{10} monitors. At three sites (AQ1, AQ2, AQ5), which were considered priority locations due to the proximity of nearest residential areas, the E-Sampler will also collect PM_{10} filter-based samples at the required interval. VOC sampling systems will also be installed at the same locations (AQ1, AQ2, AQ5) as the PM_{10} filter sampling.

Small alterations in the exact location of the five monitoring sites may occur with operational implementation of the equipment based on operational interferences and/or obstructions.

Figure 2.1 Proposed Ambient PM_{10} Monitors and Meteorological Station for Sims

Four (4) monitors, AQ1, AQ2, AQ4, and AQ5 were selected to meet the requirement in the City of Chicago Department of Public Health (CDPH) Rules for Large Recycling Facilities (City Rules), Section 3.9.21.2(a) which calls for at least one monitor placed along the fence line, at each 45-degree direction from the center of the Facility where there is a "Sensitive Area"[3] within 660 feet of the Facility boundary.

---

[3] Per the City Rules, A "Sensitive Area" means any property with a residential use, a park, a hospital, a clinic, a church, a day-care center, or a school.

The City of Chicago's Department of Planning and Development Zoning and Land Use Map was utilized to determine the location of Sensitive Areas surrounding the Sims Facility. One (1) monitor location, AQ3, was selected based on the results of the air dispersion modeling study as required in city rules Section 3.9.21.2(b).

Monitoring instruments at locations AQ1, AQ2, and AQ5 will collect continuous PM_{10}, 24-hour PM_{10} filter-based samples, and VOC samples in accordance with EPA's 1-in-3-day sampling schedule. The filter based PM_{10} samples will commence during business hours at approximately the same time of day for each sample collection day to allow for 24-hours of sampling. The typical midnight to midnight timeframe is not practical due to the type of instrument, staffing availability, and site safety concerns at midnight. Filter samples will be analyzed by the analytical laboratory for metal HAPs following Compendium Method IO-3.5. The VOC samples for compounds identified in Appendix C of the 114 request will be analyzed by an accredited laboratory, in accordance with EPA's Compendium Method TO-15A.

The following sections provide a brief description of each monitoring location.

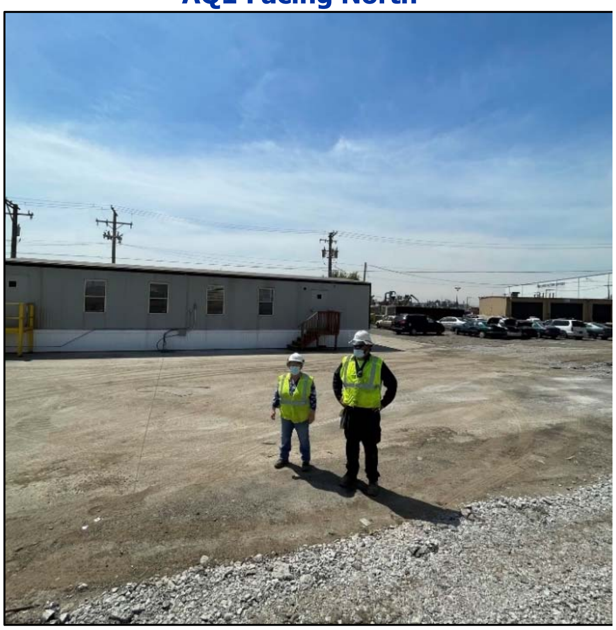
2.4.1 AQ1 Monitoring Station

The AQ1 station is proposed to be located at the north end of the Facility. The location is within 660 feet of residential areas located north of the Facility and within 660 feet of the Benito Juarez Community Academy located northeast of the Facility. This station site also is being proposed for the meteorological tower. The meteorological system will continuously monitor temperature, barometric pressure, relative humidity, wind speed, and wind direction. This station site meets U.S. EPA siting criteria and is generally free of obstructions. Figure 2.2 below presents photographs of the four cardinal directions surrounding the AQ1 site location.

Figure 2.2 Photographs of Proposed AQ1 Monitoring Station Location

AQ1 Facing North

AQ1 Facing East



AQ1 Facing South

AQ1 Facing West

2.4.2 AQ2 Monitoring Station

The AQ2 station is proposed to be located at the northeast side of the Facility. Figure 2.3 below presents photographs of the four cardinal directions surrounding the AQ2 site location. To limit the influence of obstructions adjacent to the site, this station will be placed on an elevated platform. The distance of the inlet of the PM samplers to the adjacent building will be at least twice the differential from the inlet to the top of the building.

Figure 2.3 Photographs of Proposed AQ2 Monitoring Station Location

AQ2 Facing North

AQ2 Facing East

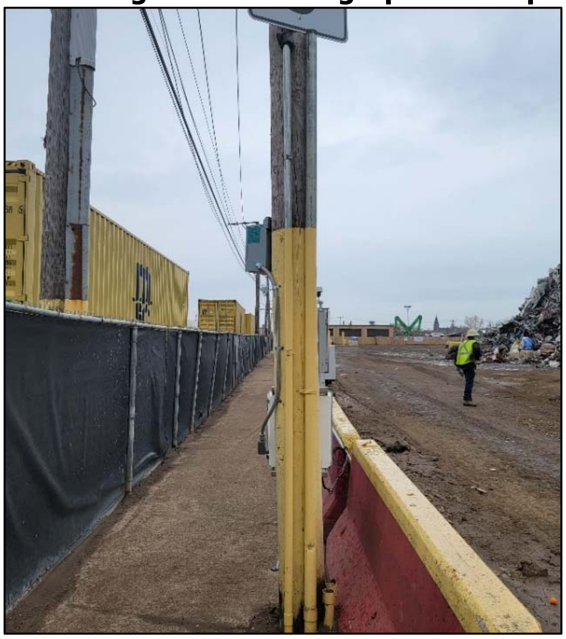
AQ2 Facing South

AQ2 Facing West

2.4.3 AQ3 Monitoring Station

The AQ3 monitoring station is proposed to be located along the west fence line of the Facility adjacent to Paulina Street. Figure 2.4 below presents photographs of the four cardinal directions surrounding the AQ3 site location.

Figure 2.4 Photographs of Proposed AQ3 Monitoring Station Location



AQ3 Facing North

AQ3 Facing East

AQ3 Facing South

AQ3 Facing West

2.4.4 AQ4 Monitoring Station

The AQ4 station, the east monitor, is proposed to be located at the southeast corner of the Facility. The location is within 660 feet of the Canalport Riverwalk park and nearest to residential areas to the east of the Facility. Figure 2.5 below presents photographs of the four cardinal directions surrounding the AQ4 site location.

Figure 2.5 Photographs of Proposed AQ4 Monitoring Station Location

AQ4 Facing North

AQ4 Facing East

AQ4 Facing South

AQ4 Facing West

2.4.5 AQ5 Monitoring Station

The AQ5 station is proposed to be located at the southwest corner of the Facility. The location is within 660 feet of the Canalport Riverwalk park and nearest to residential areas to the southwest of the Facility. Figure 2.6 below presents photographs of the four cardinal directions surrounding the AQ5 site location.

Figure 2.6 Photographs of Proposed AQ5 Monitoring Station Location

AQ5 Facing North

AQ5 Facing East

AQ5 Facing South

AQ5 Facing West

3.0 OPERATION OF AMBIENT MONITORING EQUIPMENT

All data collected shall be consistent with units in the NAAQS for PM_{10} and lead (i.e., local conditions) and consistent with the National Air Toxics Stations (NATTS) Program Technical Assistance Document (TAD) Revision 3 reporting requirements for other metal HAPs (i.e., ng m^{-3} in local conditions). VOC and other specified compound concentration measurements will also conform with the requirements outlined in the NATTS TAD. All procedures will comply with ambient monitoring practices and current U.S. EPA protocols for ambient air quality monitoring, including those for data completeness, calibration, inspection, maintenance, and site and instrument logs. Sims will maintain logs of all routine and non-routine maintenance and calibration activities associated with each near reference PM_{10} monitor. Each monitoring station will be equipped with a Campbell Scientific CR1000X data logger to record data and flow information from the PM_{10} monitors and VOC samplers, where appropriate.

The data obtained from the continuous PM_{10} monitors will be stored on-site and transmitted to a web-based data collection platform. This platform will provide notification to both field and management personnel, as well as provide access to values from each instrument.

The meteorological system located at AQ1 will continuously monitor temperature, barometric pressure, relative humidity, wind speed, and wind direction. These data will be transmitted to the same web-based platform that the continuous PM_{10} monitors utilize. Wind instruments will be located at a height of 10-meters above ground in an area clear of buildings, trees, or other obstructions. Five (5) minute and hourly averages will be calculated and stored on a directly connected datalogger.

Continuous hourly and 24-hour PM_{10} monitor data will be collected in manner so that it can be correlated with wind speed and wind direction data.

Notwithstanding the monitoring and sampling frequency and duration identified in the 114 request, after a period of monitoring and sampling data collection, Sims may petition the U.S. EPA for changes in monitoring and sampling protocol as supported by the monitoring and sampling results.

3.1 PM_{10} Sampler Calibration

The near reference continuous and filter based PM_{10} samplers will be calibrated at installation, quarterly, after major equipment repair, or when monthly flow or leak tests exceed quality assurance monitoring thresholds. All calibration results will be documented.

3.1.1 E-Sampler

The five continuous PM_{10} monitors will be calibrated quarterly by comparing results of a filter-based sample to the ambient concentrations measured by the continuous monitors and applying a correction factor as described in the manufacturer's calibration procedures. The E-Sampler has a system of calibration menus which allows the operator to calibrate the airflow control system parameters for optimal performance. The E-Samplers temperature, pressure, and leak status will be verified prior to any flow calibrations since flow calibrations are dependent on these parameters.

During each quarterly calibration which will follow the instructions provided on the E-Sampler calibration screens, the ambient temperature, ambient pressure, the external RH sensor, and flow sensors will be calibrated. All calibration results will be documented.

3.2 Meteorological Sensor Calibration

The meteorological parameters presented below will be calibrated every six months in accordance with guidance found in EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements Version 2.0 (Final) utilizing National Institute of Standards and Technology (NIST) traceable calibration standards. An initial calibration of the meteorological monitoring equipment will take place within 60 days of equipment installation.

3.2.1 Wind Direction

The cross-arm orientation will be checked using a professional compass. The wind vane will be aligned with the cross arm and set to true north. True north is distinguished from magnetic north by reading a magnetic compass and applying a correction factor for the magnetic declination. The declination will be determined from a declination calculation computer program. If the overall wind direction error (orientation plus linearity) exceeds ±5 degrees from true North, the sensor will be re-calibrated.

The wind direction sensor starting threshold will be checked using a torque gauge. The torque gauge is placed on the sensor shaft and the torque is measured. If the sensor starting threshold is greater than 0.5 meters per second (m/s), the bearings will be replaced, and the sensor will be re-calibrated.

The wind direction linearity will be checked using a direction template. The sensor response will be checked at a minimum at 30-degree increments in both clockwise and counterclockwise rotations and compared with the DAS readings. If the indicated wind direction linearity plus orientation error exceeds ±5 degrees, the sensor will be repaired and re-calibrated.

3.2.2 Wind Speed

Horizontal wind speed response checks will be performed using a synchronous motor. Sensor readings taken from the DAS will be compared to calibration values obtained from transfer functions provided in the sensor manufacturer's specifications. If the wind speed error exceeds ±0.2 m/s, then the instrument will be recalibrated.

The horizontal wind speed sensor starting threshold will be checked using a torque gauge or a torque disc. The torque device is placed on the sensor shaft and the torque is measured. If the measured torque exceeds manufacturer's tolerance specifications for wind speed sensor starting threshold of 0.5 m/s, then the bearings will be replaced, and the instrument will be recalibrated.

3.2.3 Temperature

Temperature sensor calibration will be verified by direct comparison of sensor outputs to a collocated calibrated reference standard thermometer encompassing the measurement range expected at the site. If the sensor output is more than 0.5 degrees Centigrade (°C) different from the reference, the sensor will be repaired and re-calibrated.

3.2.4 Relative Humidity

The relative humidity sensor calibration will be verified by comparison of station sensor outputs with a relative humidity reference sensor collocated at ambient conditions. If the site sensor output differs by more than ±7 percent relative humidity from the reference, the sensor will be recalibrated.

3.2.5 Precipitation

Precipitation sensor output will be verified using a standard graduated burette to add water to the gauge simulating rainfall. The volume of water required to produce ten tips will be recorded for each of three runs. This volume will be divided by the area of the gauge opening to determine the calculated amount of simulated rainfall. This amount will be compared with amounts reported by the station data logger. If the sensor differs by more than ±10% from the reference input, the sensor will be recalibrated. During calibration verification, the technician will conform that both sides of the tip bucket have similar sensitivity and provide similar, balance results.

3.3 Establishing Gravimetric Correction K-Factor for E-Sampler

One of the most important uses for the 47 mm filter system is determination of a gravimetric K-factor (slope multiplier) to correct the E-Sampler signal to compensate for local particulate characteristics. To establish the K-factor, a filter disc will be carefully weighed on a microbalance scale, and then placed into the E-Sampler filter holder and run for approximately 3 days. The filter is then reweighed by the analytical lab, and the resulting total mass of the dust on the filter is correlated with the volume of air sampled and compared with the concentrations that the E-Sampler recorded over the same time period.

To calculate the K-Factor, the following equation will be utilized:

$$\text{K-Factor} = \frac{47\ mm\ filter\ total\ concentration}{E{-}Sampler\ Total\ Light\ Scatter\ Concentration}$$

The K-factor will be determined prior to commencement of sampling and annually.

3.4 Flow and Leak Tests

Monthly, each continuous PM_{10} E-Sampler will be leak tested with a NIST-traceable reference standard to check for airflow system leaks which could affect the accuracy of the flow measurements or cause unwanted measurement biases. During each monthly flow check on the continuous E-Sampler, temperature and pressure quality control checks will also be performed with a NIST-traceable reference standard. For each FRM filter-based sampler, monthly flow and leak tests will be performed utilizing NIST-traceable reference standards. The ambient temperature and pressure sensors of each sampler will also be checked during this time. All flow and leak check test results will be documented.

3.5 Automatic Zero and Span-Tests for the Optical System of E-Sampler

To assure stable concentration data, the E-Sampler performs automated optical system zero and span self-tests on a daily schedule. A separate zero air pump activates and circulates clean air through the optical system. The E-Sampler filters the air through a 0.2-micron pore size, 99.99% efficient filter element before it enters the sensor. This is the purge filter located in the front panel of the instrument. The E-Sampler zeroes itself based on this clean air condition.

Next, the E-Sampler activates a solenoid shutter which allows a small amount of laser light from the light trap to feed back into the detector using fiber optics. This span level is used to check the response of the detector and related electronics.

3.6 1-in 3-Day Intermittent Sampling

The Met One E-Samplers will be operated in accordance with EPA's 1-in-3-day sampling schedule and PM_{10} filters will be collected for gravimetric mass and laboratory metals evaluation at the AQ1, AQ2, and AQ5 monitoring locations since these sites are located nearest to residential areas.

Metal HAP concentrations from the filter-based sampling will be determined utilizing Section 4.4.11 PM_{10} Metals Analysis by ICP/MS – EPA IO 3.5 within NATTS Program TAD Revision 3. The 1-in-3-day samples collected will undergo laboratory analysis by an analytical laboratory for the determination of metal HAPs (antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium) following Compendium Method IO-3.5. Lead concentrations from the filter-based sampling will be determined according to 40 CFR Part 50, Appendix Q.

PM_{10} filters, to be provided by the analytical laboratory, will be numbered, pre-weighted, field deployed and sampled, returned to the laboratory, extracted using microwave or hot acid, and then analyzed by inductively coupled plasma/mass spectrometry (ICP/MS) to determine the HAP metal concentrations. The laboratory process is anticipated to be a destructive process with regards to the filter.

The filters will be shipped to the field accompanied by the analytical laboratory's chain-of-custody form. The site technician will receive the filters and will perform a visual inspection of the filters to ensure there are no pinholes, chaff, loose material, separation, discoloration, or filter non-uniformity. Any filters that do not pass the visual inspection check will be set aside and not utilized for sampling. A quality control check of all data related to the filters will be performed, and relevant data will be input into the sample run log sheets for post-processing of the data.

Filters will be deployed within 30 days of pre-sample weighing date. A trip blank, which is a filter that is treated exactly as a field blank but is never placed into the sampler or exposed, will be collected at a frequency of 5% of the scheduled sampling runs. The trip blank will be used to assess possible contamination to filters during packing and transport to and from the laboratory to the sampling location.

Filters will be chilled immediately upon retrieval from the sampler(s) and shipped to the analytical laboratory. All filters will be shipped within 30 days and maintained below average ambient temperature (or at 4°C or below if average ambient sampling temperatures are <4°C) from sample end date. The analytical laboratory will record the temperature of the thermometer provided by the laboratory with the shipment when received prior to post-sampling analysis. The site technicians will fill out the provided chain-of-custody (COC) forms and ship the exposed filters directly back to the laboratory for analysis.

The analytical balance(s) to be used by the analytical laboratory for the gravimetric mass determination of PM_{10} meet the specifications identified in 40 CFR Part 50, Appendix J. Temperature and humidity conditions in the weighing room will be monitored and recorded by the analytical laboratory. New laboratory blank filters will be weighed along with the pre-sampling (tare) weighing of each set of PM_{10} filters. These laboratory blank filters will remain in the laboratory in protective containers during the field sampling and should be reweighed as a quality control check.

VOC samples will also be collected at the AQ1, AQ2, and AQ5 monitoring locations in accordance with EPA's 1-in-3-day sampling schedule. Canisters will be analyzed using EPA Compendium Method TO-15A. TO-15A provides the procedures for measuring a list of specific compounds included in Appendix C of the 114 request.

Laboratory QC checks, frequencies, acceptance criteria, and sample filter conditioning procedures will be outlined in the analytical laboratory's portion of the upcoming Quality Assurance Project Plan (QAPP).[4]

3.7 Equipment Maintenance

Manufacturer's recommendations for the E-Samplers and meteorological sensors will be followed. Instrument instruction manuals will be available at the site for reference of preventive and remedial maintenance procedures. Preventive and corrective maintenance will be documented on the calibration forms completed immediately after any maintenance. As Trinity will be the supplier of the instrumentation for the meteorological tower, we will follow the U.S. EPA guidance for the individual sensors that will be used at the meteorological tower. All sensors will meet or exceed U.S. EPA Prevention of Significant Deterioration (PSD) specifications, and Volume IV[5] will be used as a guide for station siting, sensor placement, and calibration procedures with traceable reference standards.

4 Per the 114 request, at paragraph 3.

5 Per the 114 request, at paragraph 20.

In the event of equipment or equipment component malfunction or failure, procurement of replacement equipment and/or equipment components will occur as expeditiously as possible.

4.0 QUALITY CONTROL/QUALITY ASSURANCE

Quality control (QC) refers to the operational techniques and activities that are used to fulfill requirements for quality. QC procedures applied at each step provide checks for acceptable conditions with corrective procedures specified when necessary.

Quality assurance (QA) refers to the planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy a given requirement for quality. QA is applied to location and equipment selection, equipment acquisition and installation, routine site operation, data processing, and reporting.

4.1 Quality Control

The purpose of QC procedures is to assess and document data quality and to define remedial corrective actions when operating conditions exceed pre-established limits. Routine QC procedures are designed to focus on areas most likely to have problems, based on experience and guideline documents. Table 4-1 shows the frequency of routine QC measures for the PM_{10}, VOC, and meteorological monitoring program.

Table 4-1 Schedule of Calibrations and Quality Control Checks

Activity	Frequency	Acceptable Limits
PM_{10} E-Sampler Calibration	At Install, after Sampler Replacement, and Quarterly	
Flow	Monthly	2.0±0.1 LPM
Temperature	Monthly	<±2.1°C
Barometric Pressure	Monthly	<±10.1 mmHg
System leak check	Monthly	<0.3 LPM
Wind Direction	Every 6 months	±5° <0.5 m/s
Wind Speed	Every 6 months	±0.20 m/s <0.5 m/s
Temperature	Every 6 months	±0.5°C
Relative Humidity	Every 6 months	±7 %RH
Precipitation	Every 6 months	±10%
VOC Canister Systems	At install	Checked for contamination
Canisters	Prior to sample collection	>28 in Hg

The automated VOC sampling equipment will be tested for contamination prior to the start of the sampling project. This is accomplished by first flushing each system with clean ambient air followed by ultra-pure air and then connecting a clean, evacuated canister to each system. The canister, with flow controller mounted will be allowed to sample ultra-pure air for a normal 24-hour sampling period. Samples will be sent to the analytical laboratory for analysis to confirm that each system was free of contamination. Field sample sheets will accompany samples and the required COC documentation will accompany each shipment.

The data logger at the monitoring site is interrogated every hour to download and process the data. Abnormal data values or apparent problems are reported immediately to the program manager who initiates corrective action and determines if a special visit to the site is required.

Computerized inspection of the continuous PM_{10} data is performed daily on the five-minute average data after remotely interrogating each monitoring site datalogger via modem using an outlier program. The data are downloaded and subjected to a series of quality tests. The data files are input to a program which performs a series of quality control (QC) tests as listed in Table 4-2. The QC program produces a report that identifies each value in the data file that fails one or more of the listed tests.

Table 4-2 Quality Control Checks Imposed by Data QC Program

Parameter	Less Than	Greater Than	Constant For
Wind Speed	0 m/s	35 m/s	2 hours
Wind Direction	0 deg	360 deg	2 hours
Temperature	-30 deg C	45 deg C	30 minutes
Relative Humidity	3%	102%	16 hours
Precipitation	0 inches	1 inch in 24 hours	N/A
Continuous PM_{10}	-5 ug/m^3	150 ug/m^3	4 hours
Instrument Clock Time	30 sec.	30 sec	>1 minute
Battery Voltage	11.5 V	16 V	N/A

4.2 Quality Assurance

Precision and accuracy checks are both elements of QA. Precision checks are a measure of agreement among individual measurements of the same parameter, usually under prescribed similar conditions. Accuracy is the degree of agreement between an accepted reference measurement and the field measurement. Accuracy may be expressed as a total difference, or as a percentage of the reference value, or as a ratio.

Precision checks will be performed using the continuous measurements and the results of the PM_{10} filter-based samples from the E-samplers located at AQ1, AQ2, and AQ5. Accuracy of ambient air sampling equipment is measured in terms of the accuracy of the flow rate measurement. Accurate determination of the air volume drawn through the air sampler is essential to the concentration calculation. Flow rates of the air samplers will be determined pre- and post-sampling using calibrated equipment appropriate to the sampling device.

Duplicate VOC samples will be collected at a 10% frequency at each VOC monitoring location. Duplicate samplers will be collected for the required 24-hour sampling period and will collected through a common manifold. Duplicate samples will be compared to the primary sample to determine the precision. VOC duplicate sample precision will follow NATTS recommendations of ≤25% relative percent difference for target compounds ≥five-fold the laboratory minimum detection limit (MDL).

Preventive maintenance will be part of the air samplers' QA program. Preventive maintenance is a combination of preventive and remedial actions taken to prevent or correct failure of the monitoring systems. Preventive maintenance for the air samplers includes inspection and cleaning of the inlets.

4.3 Data Validation

PM_{10} and meteorological data will be stored in each station’s data logger memory as one-minute and hourly averages computed from secondly values. Data validation will be performed on the hourly average data. An hourly average will be computed when at least 45-minutes of data are available for the hour. Each month, the proper operation of the PM_{10} monitors and meteorological sensors will be verified by reviewing the leak checks, calibration records, audit results, and field notes from the site technicians prior to formal acceptance of these data.

Data will also be subject to a series of quality control checks. The quality assurance software is used to generate flags or warnings that the parameter value is outside of a normally acceptable range. The outlier program does not invalidate data or erase file records based on these outlier tests. Raw data files are archived and never modified. It will be left to a qualified meteorologist to review the results of the outlier program in conjunction with the data parameter plots and initiate corrective actions if warranted (site visit or data invalidation).

Per EPA’s Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program, EPA recommends the use of flags or result qualifiers to identify potential problems with data (or a sample). According to EPA, a flag is an indicator of the fact and the reason that a data value (a) did not produce a numeric result, (b) produced a numeric result but it is qualified in some respect relating to the type or validity of the result, or (c) produced a numeric result but for administrative reasons is not to be reported outside the organization.

4.4 Performance Audits

Quality assurance performance audits on the continuous PM_{10} monitors will be conducted once per quarter. The meteorological tower will be audited twice per year. An independent auditor with NIST-traceable audit reference standards will conduct the audits.

APPENDIX A. EQUIPMENT SPECIFICATION SHEETS

E-Sampler Dual Ambient Monitor/Sampler

The E-SAMPLER is the most feature-packed light-scatter Aerosol Monitor available. Whatever your monitoring needs, the E-sampler will provide accurate, dependable and relevant data.

The E-SAMPLER is a dual technology instrument that combines the unequaled realtime measurement of light scatter with the accuracy standard of filter methods. The simple filter loading process testifies to the seamless blending of both technologies. Filters can be extracted and replaced in less than one minute. Filter medium can be selected based on laboratory analysis requirements.

Particulate loading on the filter does not reduce performance due to the Met One actual flow control protocol. Ambient temperature and pressure are measured and actual flow is calculated and controlled by the E-SAMPLER microprocessor, independent of filter loading change.

The E-SAMPLER provides real-time particulate measurement through near-forward light scattering. An internal rotary vane pump draws air at 2 LPM into the sensing chamber where it passes through visible laser light. Aerosols in the air scatter light in proportion to the particulate load in the air. Scattered light is collected by precise glass optics and focused on a PIN diode.

Rugged state of the art electronics measure the intensity of the focused light and output a signal to the CPU. The output is linear to concentrations greater than 65,000 ug/m^3. Every E-SAMPLER is factory calibrated using polystyrene latex spheres of known index of refraction and diameter at multiple points to validate linearity.

Features:

- Programmable Auto-Zero
- Programmable Auto-Span
- Auto-ranging (1 to 65000 μm/m^3)
- Automatic Flow Control
- Protocol
- Internal Battery (30 Hours Operation without heater & 10 Hours with heater.)
- Laser-Diode Precise Optical Engine
- Integral 47mm Analysis Filter
- Ambient Pressure and Temperature
- Internal Data-logger
- PM_{10}, $PM_{2.5}$, PM_1, TSP Monitoring
- Aluminum Weatherproof Enclosure
- Purge-Air protected Optics
- Completely Self-Contained
- No Tools Filter Replacement

Applications:

- Ambient Air Monitoring
- Remediation Site Perimeter Monitoring
- Indoor Air Quality Monitoring
- Source Monitoring
- Visibility Monitoring
- Mobile Monitoring

Measurement Principles:	Light Scatter and 47mm low flow gravimetric filter sampler.
Available Cut Points:	TSP Inlet Standard. PM_{10}, $PM_{2.5}$, and PM_1 sharp-cut cyclone inlets available.
Measurement Range:	0 to 65 mg/m^3 (0 to 65,530 µg/m^3) dynamic range. 16 bit digital range.
Nephelometer Accuracy:	± 10% to gravimetric method typical when K-factored to local particulate type.
Gravimetric Accuracy:	± 8% of NIOSH 0600.
Precision:	Greater of 3 µg/m^3 or 2%.
Data Storage Resolution:	1 µg/m^3
Data Storage Intervals:	User-Selectable 1, 5, 10, 15, 30, or 60 minute averages.
Nephelometer Interval:	1-second measurements, available on analog output and display.
Sample Cycles:	Continuous operation or programmable scheduled sample runs.
Particle Size Sensitivity:	0.1 to 100 micron. Optimal sensitivity 0.5 to 10 micron particles.
Laser Type:	Diode Laser, 5 mW, 670nm. Visible red.
Long Term Stability:	5% with clean optics.
Flow Rate:	2.0 liters/minute ± 0.1 lpm. Actual volumetric flow.
Pump Type:	10,000 hour brushless diaphragm sample pump and secondary purge pump.
Gravimetric Filter Type:	47mm disc filters (not included). Accepts standard FRM filter holder cartridges.
Automatic Zero and Span:	User-selectable 15 min, 1 hour, 2 hour, 12 hour, or 24 hour intervals. 2.8 min cycle.
Internal Battery:	12V, 12 Amp-Hour. Yuasa NP12-12 or equivalent, Optional lead acid battery.
Internal Battery Run Time:	Up to 30 hours with inlet heater off. Up to 10 hours with inlet heater on.
Power Supply:	Universal 100-240 VAC input, 15 VDC output power supply included. Compatible with solar power kits or external batteries using optional DC power cable.
Power Consumption:	1.1 amps @ 12 VDC (15 Watts) max continuous draw, running with inlet heater on. 0.35 amps (4.2 Watts) running with inlet heater off.
Operating Temperature:	0 to +50°C . (Ambient Temperature Sensor Range -30 to +50°C).
Barometric Pressure:	60,000 to 104,000 Pascal pressure sensor range.
Ambient Humidity Range:	0 to 90% RH, non-condensing.
Humidity Control:	Automatic 10 Watt inlet heater module controlled to sample RH setpoint. Sample RH sensor standard. Optional EX-593 ambient RH sensor available.
Approvals:	CE, ISO-9001. Designed to agree with EPA Class I and Class III FRM/FEM particulate samplers and monitors. Not an EPA-designated equivalent method.
User Interface:	Menu-driven interface with 4x20 character LCD display and dynamic keypad.
Analog Voltage Output:	0-1, 0-2.5, or 0-5 volt DC output. User-set range with 1-second real-time output.
Serial Interface:	RS-232 duplex serial port for PC, datalogger, or modem communications.
Alarm Contact Closure:	Normally closed contact closure relay output. Contact rating 0.5A @ 100V DC max.
Compatible Software:	Comet™ (included), Air Plus™, terminal programs such as HyperTerminal®
Alarm Reporting:	Available through serial port data files, display, and relay output.
Memory:	4369 data logger records (182 days @ 1 record/hr, 3 days @ 1 record/min).
Factory Service Interval:	24 Months typical, under continuous use in normal ambient air.
Mounting Options:	Pole or wall mount bracket standard. Optional EX-905 tripod recommended.
Unit Weight:	6.4 kg (14 lbs) without tripod, battery, or optional accessories.
Unit Dimensions:	65cm high, 27cm wide, 16.5cm deep. (25.5” x 10.5” x 6.5”). With inlet assembly

Specifications are subject to change at any time.

Met One Instruments, Inc.
1600 Washington Blvd. Grants Pass, Oregon 97526 **Phone:** 541.471.7111
Sales: sales@metone.com | **Service:** service@metone.com | **Website:** www.metone.com

wind

High Performance Wind Sensor for Air Quality Applications

YOUNG

Model 05305

Wind Monitor-AQ

The Wind Monitor-AQ is a high resolution wind sensor designed specifically for air quality applications. It combines simple, corrosion-resistant construction with low threshhold, fast response and excellent fidelity.

The Wind Monitor-AQ meets the requirements of the following regulatory agencies:

U.S. Environmental Protection Agency – Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD).

U.S. Nuclear Regulatory Agency – NRC Regulatory Guide 1.23 Meteorological Programs in Support of Nuclear Power Plants.

American Nuclear Society – Standard for Determining Meteorological Information at Power Plants.

Wind speed is sensed by a lightweight, carbon fiber thermoplastic (CFT), helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. Slip rings and brushes are not used.

The wind direction sensor is a lightweight vane with performance characteristics that assure excellent fidelity in fluctuating wind conditions. Vane position is sensed by a precision potentiometer. Output is a DC voltage directly proportional to vane angle.

The instrument body is UV stabilized plastic with stainless steel and anodized aluminum fittings. Precision grade, stainless steel ball bearings are used throughout. Transient protection and cable terminations are located in a convenient junction box. The instrument mounts on standard 1 inch pipe.

The Wind Monitor-AQ is available with two additional output signal options. **Model 05305V** offers calibrated voltage outputs, convenient for use with many dataloggers. **Model 05305L** provides a calibrated 4-20 mA current signal for each channel, useful in high noise areas or for long cables (up to several kilometers). Signal conditioning electronics are integrated into the sensor junction box.

Ordering Information — MODEL

WIND MONITOR-AQ **05305**
WIND MONITOR-AQ VOLTAGE OUTPUTS **05305V**
WIND MONITOR-AQ 4-20mA OUTPUTS **05305L**

Specifications

Range:
Wind speed: 0-50 m/s (112 mph)
Azimuth: 360° mechanical, 355° electrical (5° open)

Accuracy:
Wind speed: ±0.2 m/s (0.4 mph) or 1% of reading
Wind direction: ±3 degrees

Threshold:*
Propeller: 0.4 m/s (.9 mph)
Vane: 0.5 m/s (1.0 mph) at 10° displacement

Dynamic Response:*
Propeller distance constant (63% recovery) 2.1 m (6.9 ft)
Vane delay distance (50% recovery) 1.2 m (3.9 ft)
Damping ratio: 0.45
Damped natural wavelength: 4.9 m (16.1 ft)
Undamped natural wavelength: 4.4 m (14.4 ft)

Signal Output:
Wind speed: magnetically induced AC voltage, 3 pulses per revolution. 1800 rpm (90 Hz) = 9.2 m/s (20.6 mph)
Azimuth: analog DC voltage from conductive plastic potentiometer – resistance 10K Ω, linearity 0.25%, life expectancy – 50 million revolutions

Power Requirement:
Potentiometer excitation: 15 VDC maximum

Dimensions:
Overall height: 38 cm (15.0 in)
Overall length: 65 cm (25.6 in)
Propeller: 20 cm (7.9 in) diameter
Mounting: 34 mm (1.34 in) diameter (standard 1 inch pipe)

Weight:
Sensor weight: 0.7 kg (1.5 lbs)
Shipping weight: 2.3 kg (5 lbs)

**Nominal values, determined in accordance with ASTM standard procedures. Shielded bearings lubricated with Type LO-1 light General Purpose Instrument Oil.*

MODEL 05305V **Voltage outputs**

Power Requirement:
8-24 VDC (5 mA @ 12 VDC)

Operating Temperature:
-50 to 50° C

Output Signals:
WS: 0-2.5 VDC (0-50 m/s)
WD: 0-5 VDC (0-360°)

MODEL 05305L **4-20 mA outputs**

Power Requirement:
8-30 VDC (40 mA max.)

Operating Temperature:
-50 to 50° C

Output Signals:
4-20 mA full scale

CE *Complies with applicable CE directives.*
Specifications subject to change without notice.

R.M. YOUNG COMPANY
2801 Aero Park Drive
Traverse City, Michigan 49686 USA
TEL: (231) 946-3980 FAX: (231) 946-4772
E-mail: met.sales@youngusa.com
Web Site: www.youngusa.com

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

HygroVUE10

Digital Temperature and Relative Humidity Sensor with M12 Connector

Rugged, Reliable, and Flexible

Simple to use and easy to maintain

Overview

The HygroVUE™10 offers a combined temperature and relative humidity element in an advanced digital sensor that is ideal for weather networks. The electronics within the sensor provide accurate measurements, and the sensor is easy to use. The digital SDI-12 output allows a simple connection and measurement by many data logging systems. Another benefit is that this digital output avoids the extra errors associated with measuring analog sensors.

A stainless-steel mesh filter on the HygroVUE™10 minimizes the effects of dust and dirt on the sensor while allowing air exchange around the sensor element and reducing the chances that condensation remains inside the filter cap. A small PTFE membrane filter is bonded to the surface of the element, which prevents any finer dust or mold from directly influencing the measurement.

Because the sensor housing is designed to withstand permanent exposure to various weather conditions and to fit inside a range of radiation shields (including compact shields), the HygroVUE™10 is truly suitable for a wide range of monitoring applications.

The HygroVUE™10 utilizes a latest-generation, Swiss-made, combined relative humidity and temperature element based on CMOSens® technology that offers good measurements, accuracy, and stability. Each element of the HygroVUE™10 is individually calibrated with the calibration corrections stored on the chip. You can easily change the sensor element in the field, which reduces your downtime and calibration costs.

Benefits and Features

- Uses a combined, pre-calibrated digital humidity and temperature element
- Field-changeable element for fast, on-site recalibration
- Digital SDI-12 output, allowing long cables with no added errors
- Simple data logger programming
- Low power consumption
- Wide operating voltage
- Rugged design with potted electronics
- Standard M12 connector with IP67 sealing rating

Detailed Description

Mounting

When you use the HygroVUE™10 outdoors, it is standard practice to install the sensor within a housing, known as a shield. The shield prevents solar radiation from heating the sensor and creating measurement errors. The radiation shield also provides a degree of protection from adverse weather, such as hail or driving rain. The most common type of shield is a relatively small, naturally ventilated screen that is low maintenance and requires no power.

The HygroVUE™10 is specifically designed for field use with dimensions to suit common radiation shields. (Campbell Scientific recommends the RAD10E 10-Plate Solar Radiation Shield.) You can mount the RAD10E on vertical or horizontal poles.

Field Calibration

Calibration is easy to carry out by simply changing the sensor element. As each sensor element is individually calibrated, no further adjustments of the sensor are required. This means that when you change the element, it returns the sensor to the factory calibration state for both temperature and humidity—without interrupting your measurement collection for long periods.

Specifications

Sensing Element	SHT35 modified by Campbell Scientific
Communication Standard	SDI-12 V1.4 (responds to a subset of commands)
Supply Voltage	7 to 28 Vdc
EMC Compliance	Tested and conforms to IEC61326:2013.
Standard Operating Temperature Range	-40° to +70°C
Main Housing Material	UV stable, white PET-P
Electronics Sealing Classification	IP67
Sensor Protection	Outer glass-filled polypropylene cap fitted with a stainless-steel mesh dust filter with nominal pore size of < 30 µm. The sensor element has a PTFE protective film with a filtration efficiency of > 99.99% for particles of 200 nm or larger size.
Sensor Connector	M12, male, 4-pole, A-coded
Cable	Polyurethane sheathed, screened cable, nominal diameter 4.8 mm (0.19 in.)
Field-Replaceable Chip or Recalibrate	Field-replaceable chip
Sensor Cap Diameter	12.5 mm (0.5 in.)
Body Diameter at Connector	18 mm (0.7 in.)
Length	180 mm (7.1 in.) without cable fitted
Sensor Body Weight	50 g (1.8 oz)
Weight	250 g (8.8 oz) with 5 m (16.4 ft) cable

Relative Humidity

Measurement Range	0 to 100% RH
Accuracy	±2% (at 25°C, over the range 80 to 100% RH) *-NOTE- The accuracy figures quoted are the 95% confidence limits relative to factory standards.* ±1.5% (at 25°C, over the range 0 to 80% RH)
Short-Term Hysteresis	< ±1% RH
Additional Errors at Other Temperatures	< ±1% RH (over -40° to +60°C)
Long-Term Stability	±0.5% per year (maximum drift in clean air conditions)
Reported Resolution	0.001% RH
Repeatability	0.05% RH (3σ noise level)
Response Time with Filter	8 s (63% response time in air moving at 1 m/s)

Air Temperature

Measurement Range	-40°C to +70°C
-NOTE-	*The accuracy figures quoted are the 95% confidence limits relative to factory standards.*
Accuracy	±0.1°C (over the range -20 to +60°C)

	❱ ±0.2°C (over the range -40 to +70°C)
Long-Term Drift	< 0.03°C per year
Reported Resolution	0.001°C
Repeatability	0.04°C (3σ noise level)
Response Time with Filter	< 130 s (63% response time in air moving at 1 m/s)
Calibration Traceability	NIST and NPL standards

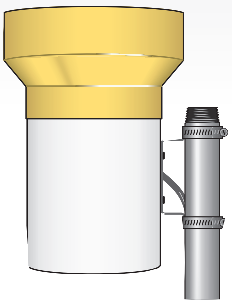
Maximum Current Drain

Quiescent	50 µA
During Measurement	0.6 mA (takes 0.5 s)

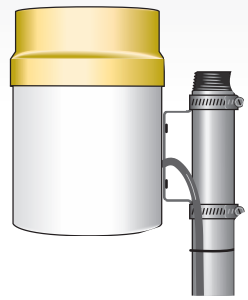
CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

TE525, TE525WS, and TE525MM

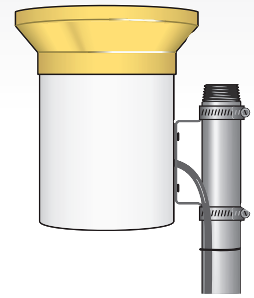
Texas Electronics Tipping Bucket Rain Gages



The TE525WS conforms to the National Weather Service recommendation for an 8-inch funnel orifice.



The TE525 is widely used in environmental monitoring applications.



The TE525MM measures rainfall in metric rather than US units.

Overview

The TE525-series tipping bucket rain gages are manufactured by Texas Electronics. They funnel precipitation into a bucket mechanism that tips when filled to a calibrated level. A magnet attached to the tipping mechanism actuates a switch as the bucket tips. The momentary switch closure is counted by the pulse-counting circuitry of Campbell Scientific dataloggers.

Benefits and Features

- High precision
- Integral bubble level
- Compatible with all Campbell Scientific dataloggers (including the CR200(X) series)
- Compatible with the CWS900-series interfaces, allowing it to be used in a wireless sensor network

Mounting

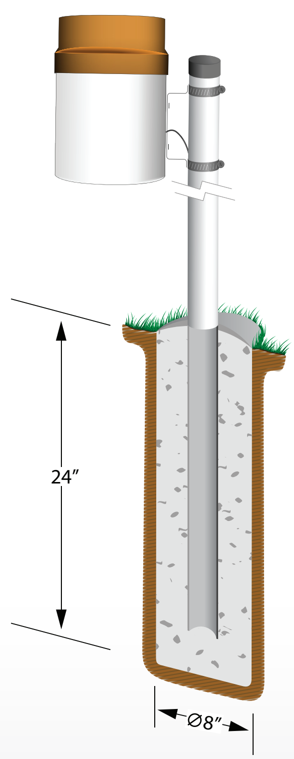
The TE525-series rain gages mount to a CM300-series Mounting Pole or a user-supplied 1.5 in. IPS pole. Several pedestal options are available to secure a CM300-series pole to the ground (see Ordering Information on page 2). Accurate measurements require the gage to be level.

Wind Screen

Campbell Scientific offers the 260-953 Wind Screen to help minimize the affect of wind on the rain measurements. This wind screen consists of 32 leaves that hang freely and swing as wind moves past them.

Snowfall Adapter

Campbell Scientific's CS705 Snowfall Conversion Adapter uses antifreeze to melt snow, allowing the TE525WS to measure the water content of snow. The CS705 cannot be directly used with either the TE525 or TE525MM. However, both the TE525 and TE525MM can be converted to a TE525WS by returning them to Campbell Scientific. For more information, refer to the CS705 brochure.



At left is a TE525 mounted onto a CM310 pole that is embedded directly in a concrete pad (-NP no pedestal base option).

Ordering Information

Tipping Bucket Raingages

Enter the cable length, in feet, after the -L. Recommended length is 25 ft, but many customers will order a 50 ft cable to place the gage away from the tower or tripod. Must choose a cable termination option.

TE525WS-L Tipping bucket with 8 inch diameter orifice and 0.01 in. tips.

TE525-L Tipping bucket with 6 inch diameter orifice and 0.01 in. tips.

TE525MM-L Tipping bucket with 24.5 cm diameter orifice and 0.1 mm tips.

Cable Termination Options (choose one)

-PT Cable terminates in stripped and tinned leads for direct connection to a datalogger's terminals.

-PW Cable terminates in a connector for attachment to a prewired enclosure.

-CWS Cable terminates in a connector for attachment to a CWS900-series interface. Connection to a CWS900-series interface allows this sensor to be used in a wireless sensor network.

-C Cable terminates in a connector for attachment to a CS110 Electric Field Meter or ET107 weather station.

-RQ Cable terminates in a connector for attachment to a RAWS-P Permanent Remote Automated Weather Station. This option is not offered for the TE525MM.

Mounting Poles

CM300 23 inch Mounting Pole with Cap

CM305 47 inch Mounting Pole with Cap

CM310 56 inch Mounting Pole with Cap

Pedestal Options for Mounting Poles (choose one)

-NP No Pedestal Base

-PJ CM340 Pedestal J-Bolt Kit

-PS CM350 Pedestal Short Legs (23 in. legs)

-PL CM355 Pedestal Long Legs (39 in. legs)

Common Accessories

CS705 Snowfall adapter for the TE525WS

10869 Four one-gallon containers of 50:50 PG:E Antifreeze; only U. S. ground shipments

CM270 CM270 Mounting Kit

260-953 Novalynx Alter-type Rain Gage Wind Screen

Specifications

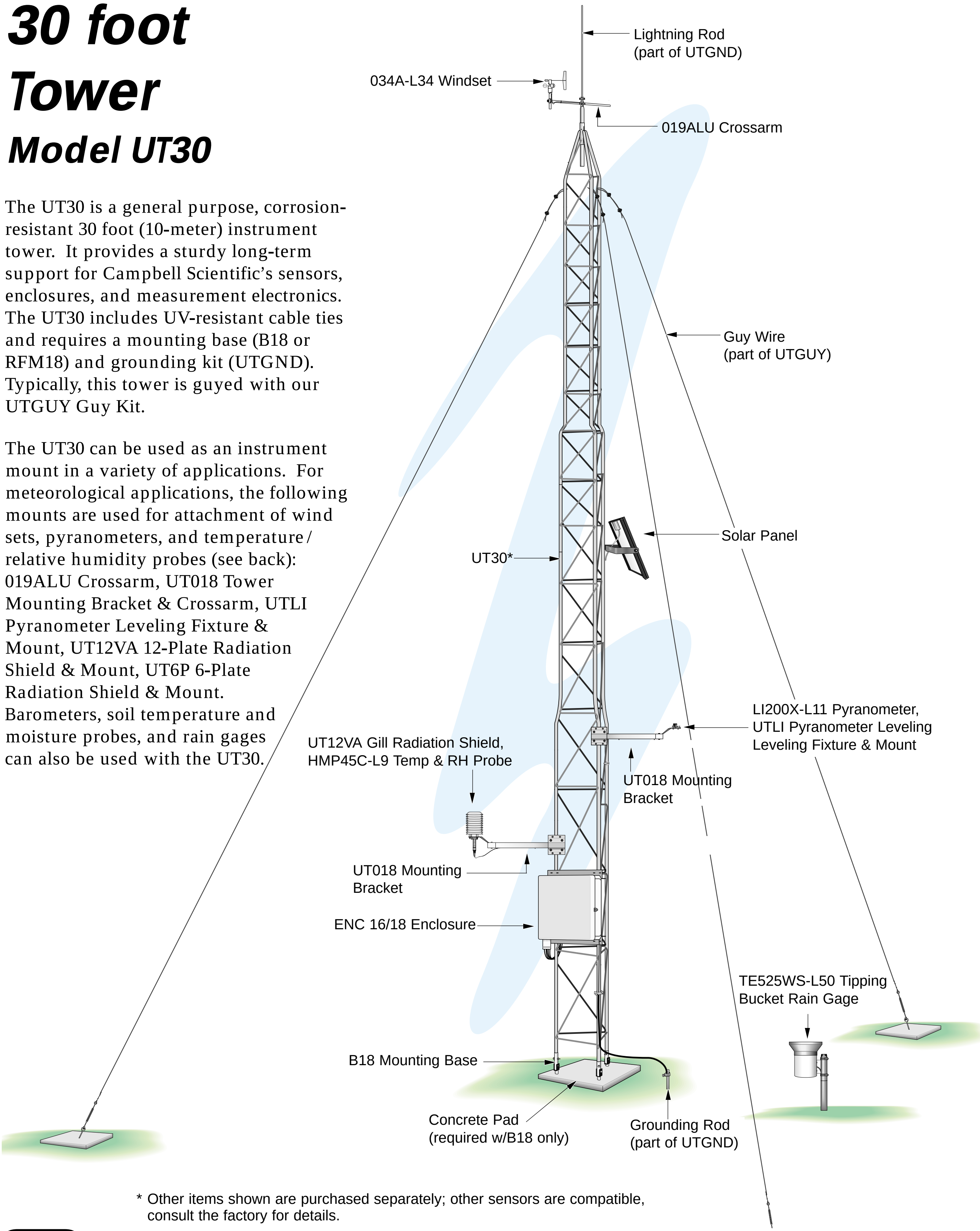
	TE525	TE525WS	TE525MM
Sensor Type	tipping bucket/potted magnetic momentary contact reed switch		
Switch Ratings	30 Vdc at 2 A; 115 Vac at 1 A; closure time: 135 ms; bounce settling time: 0.75 ms		
Bucket Material	white powder coated spun aluminum		
Funnel Collector Material	gold anodized spun aluminum		
Screen Material	gold anodized spun aluminum		
Locking Snap Ring Material	stainless steel		
Operating Temperature	0° to +50°C (32° to 125°F)		
Resolution	1 tip		
Volume per Tip	4.73 ml/tip (0.16 fl. oz/tip)	8.24 ml/tip (0.28 fl. oz/tip)	4.73 ml/tip (0.16 fl. oz/tip)
Rainfall per Tip	0.01 in. (0.254 mm)		0.1 mm (0.004 in)
Accuracy	1.0% up to 2 in/hour (50 mm/hr)		
Knife Edge Funnel Collector Diameter	15.4 cm (6.1 in)	20.3 cm (8 in)	24.5 cm (9.7 in)
Height	24.1 cm (9.5 in)	26.7 cm (10.5 in)	29.2 cm (11.5 in)
Tipping Bucket Weight	0.9 kg (2 lb)	1 kg (2.2 lb)	1.1 kg (2.4 lb)
Cable	2-conductor shielded cable		
Cable Weight	0.1 kg (0.2 lb) per 10 ft length		
Warranty	three year		

30 foot Tower

Model UT30

The UT30 is a general purpose, corrosion-resistant 30 foot (10-meter) instrument tower. It provides a sturdy long-term support for Campbell Scientific's sensors, enclosures, and measurement electronics. The UT30 includes UV-resistant cable ties and requires a mounting base (B18 or RFM18) and grounding kit (UTGND). Typically, this tower is guyed with our UTGUY Guy Kit.

The UT30 can be used as an instrument mount in a variety of applications. For meteorological applications, the following mounts are used for attachment of wind sets, pyranometers, and temperature/relative humidity probes (see back): 019ALU Crossarm, UT018 Tower Mounting Bracket & Crossarm, UTLI Pyranometer Leveling Fixture & Mount, UT12VA 12-Plate Radiation Shield & Mount, UT6P 6-Plate Radiation Shield & Mount. Barometers, soil temperature and moisture probes, and rain gages can also be used with the UT30.



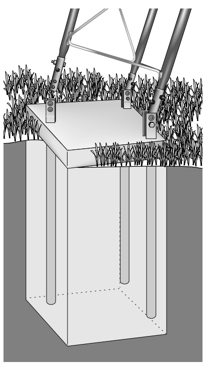
* Other items shown are purchased separately; other sensors are compatible, consult the factory for details.

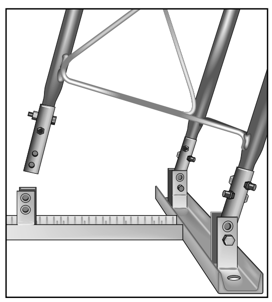
CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (435) 753-2342 • FAX (435) 750-9540 • www.campbellsci.com

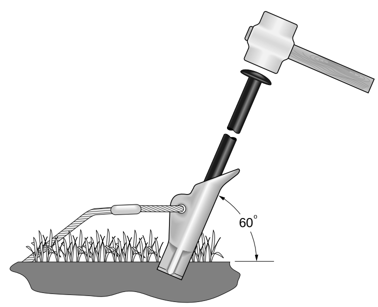
Specifications

Crossarm measurement height:	33 ft (10 m)
Shipping weight:	65 lbs (29 kg)
Material:	Hardened Drawn 6063-T832 aluminum
OD of vertical pipe:	1” (2.5 cm)
OD of cross support pipes:	0.375” (0.953 cm)
Guyed tower area requirements:	~34 ft diameter
Required concrete pad dimensions (B18 base only):	36”L x 36”W x 48”D (91 x 91 x 122 cm) This assumes heavy soil; light shifting, or sandy soils require a larger concrete pad.

UT30 Accessories

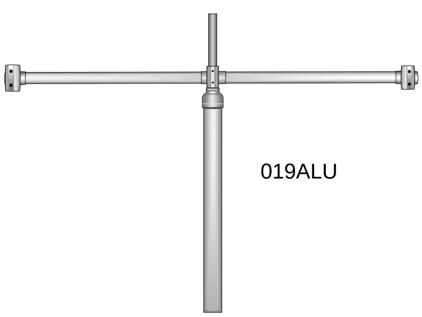

B18

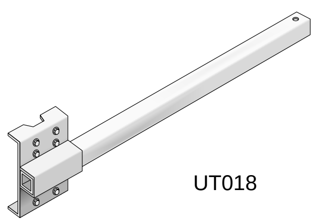

RFM18

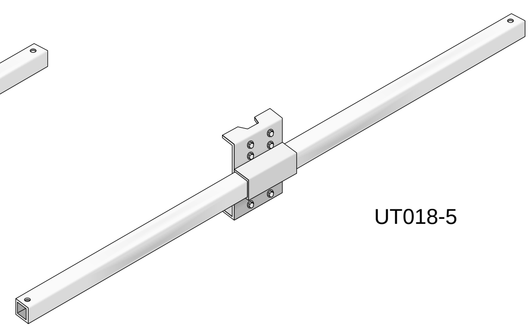


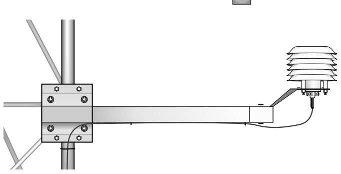
UTDUK

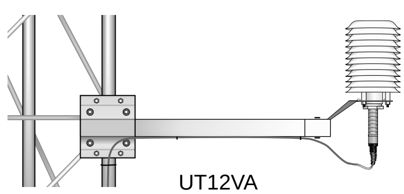

UTEYE

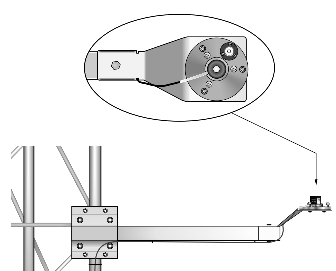

019ALU


UT018


UT018-5


UT6P


UT12VA


UTLI

CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (435) 753-2342 • FAX (435) 750-9540
Offices also located in: Australia • Brazil • Canada • England • France • South Africa

Printed June, 2000

CR1000X Specifications

Datalogger

Electrical specifications are valid over a -40 to +70 °C, non-condensing environment, unless otherwise specified. Extended electrical specifications (noted as XT in specifications) are valid over a -55 to +85 °C non-condensing environment. Recalibration is recommended every three years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.

System specifications

Processor: Renesas RX63N (32-bit with hardware FPU, running at 100 MHz)

Memory:

- Total onboard: 128 MB of flash + 4 MB battery-backed SRAM
  - Data storage: 4 MB SRAM + 72 MB flash (extended data storage automatically used for auto-allocated Data Tables not being written to a card)
  - CPU drive: 30 MB flash
  - OS load: 8 MB flash
  - Settings: 1 MB flash
  - Reserved (not accessible): 10 MB flash
- Data storage expansion: Removable microSD flash memory, up to 16 GB

Program Execution Period: 1 ms to 1 day

Real-Time Clock:

- Battery backed while external power is disconnected
- **Resolution**: 1 ms
- **Accuracy**: ±3 min. per year, optional GPS correction to ±10 µs

Wiring Panel Temperature: Measured using a 10K3A1A BetaTHERM thermistor, located between the two rows of analog input terminals.

Physical specifications

Dimensions: 23.8 x 10.1 x 6.2 cm (9.4 x 4.0 x 2.4 in); additional clearance required for cables and wires.

Weight/Mass: 0.86 kg (1.9 lb)

Case Material: Powder-coated aluminum

Power requirements

Protection: Power inputs are protected against surge, over-voltage, over-current, and reverse power. IEC 61000-4 Class 4 level.

Power In Terminal:

- **Voltage Input**: 10 to 18 VDC
- **Input Current Limit at 12 VDC**:
  - 4.35 A at -40 °C
  - 3 A at 20 °C
  - 1.56 A at 85 °C
- 30 VDC sustained voltage limit without damage.

USB Power: Functions that will be active with USB 5 VDC include sending programs, adjusting data logger settings, and making some measurements. If USB is the only power source, then the CS I/O port and the 5V, 12V, and SW12 terminals will not be operational.

Internal Lithium Battery: AA, 2.4 Ah, 3.6 VDC (Tadiran TL 5903/S) for battery-backed SRAM and clock. 3-year life with no external power source.

Average Current Drain:

Assumes 12 VDC on POWER IN terminals.

- **Idle**: <1 mA
- **Active 1 Hz Scan**: 1 mA
- **Active 20 Hz Scan**: 55 mA
- **Serial** (RS-232/RS-485): Active + 25 mA
- **Ethernet Power Requirements**:
  - **Ethernet 1 Minute**: Active + 1 mA
  - **Ethernet Idle**: Active + 4 mA
  - **Ethernet Link**: Active + 47 mA

Vehicle Power Connection: When primary power is pulled from the vehicle power system, a second power supply OR charge regulator may be required to overcome the voltage drop at vehicle start-up.

Power output specifications

System power out limits (when powered with 12 VDC)

Temperature (°C)	Current Limit[1] (A)
–40°	4.53
20°	3.00
70°	1.83
85°	1.56
[1] Limited by self-resetting thermal fuse	

12V and SW12V power output terminals

12V, SW12-1, and SW12-2: Provide unregulated 12 VDC power with voltage equal to the Power Input supply voltage. These are disabled when operating on USB power only.

SW12 current limits	
Temperature (°C)	**Current Limit [1] (mA)**
–40°	1310
0°	1004
20°	900
50°	690
70°	550
80°	470
[1] Thermal fuse hold current.	

5 V and 3.3 V

5V: One regulated 5 V output. Supply is shared between the 5V terminal and CS I/O DB9 5 V output.

- **Voltage Output**: Regulated 5 V output (±5%)
- **Current Limit**: 230 mA

C as power output

- C Terminals:
  - **Output Resistance (R_O)**: 150 Ω
  - **5 V Logic Level Drive Capacity**: 10 mA @ 3.5 VDC
  - **3.3 V Logic Level Drive Capacity**: 10 mA @ 1.8 VDC

CS I/O pin 1

5 V Logic Level Max Current: 200 mA

Voltage excitation

VX: Four independently configurable voltage terminals (VX1-VX4). When providing voltage excitation, a single 16-bit DAC shared by all VX outputs produces a user-specified voltage during measurement only.VX terminals can also be used to supply a selectable, switched, regulated 3.3 or 5 VDC power source to power digital sensors and toggle control lines.

	Range	Resolution	Accuracy	Maximum Source/Sink Current[1]
Voltage Excitation	±4 V	0.06 mV	±(0.1% of setting + 2 mV)	±40 mA
Switched, Regulated	+3.3 or 5 V	3.3 or 5 V	±5%	50 mA
[1] Exceeding current limits causes voltage output to become unstable. Voltage should stabilize when current is reduced to within stated limits.				

Analog measurements specifications

16 single-ended (SE) or 8 differential (DIFF) terminals individually configurable for voltage, thermocouple, current loop, ratiometric, and period average measurements, using a 24-bit ADC. One channel at a time is measured.

Voltage measurements

Terminals:

- **Differential Configuration**: DIFF 1H/1L – 8H/8L
- **Single-Ended Configuration**: SE1 – SE16

Input Resistance: 20 GΩ typical

Input Voltage Limits: ±5 V

Sustained Input Voltage without Damage: ±20 VDC

DC Common Mode Rejection:

- > 120 dB with input reversal
- ≥ 86 dB without input reversal

Normal Mode Rejection: > 70 dB @ 60 Hz

Input Current @ 25 °C: ±1 nA typical

Filter First Notch Frequency (f_{N1}) Range: 0.5 Hz to 31.25 kHz (user specified)

Analog Range and Resolution:

		Differential with Input Reversal		Single-Ended and Differential without Input Reversal	
Notch Frequency (f_{N1}) (Hz)	Range[1] (mV)	RMS (µV)	Bits[2]	RMS (µV)	Bits[2]
15000	±5000 ±1000 ±200	8.2 1.9 0.75	20 20 19	11.8 2.6 1.0	19 19 18
50/60[3]	±5000 ±1000 ±200	0.6 0.14 0.05	24 23 22	0.88 0.2 0.08	23 23 22
5	±5000 ±1000 ±200	0.18 0.04 0.02	25 25 24	0.28 0.07 0.03	25 24 23

[1] Range overhead of ~5% on all ranges guarantees that full-scale values will not cause over range

[2] Typical effective resolution (ER) in bits; computed from ratio of full-scale range to RMS resolution.

[3] 50/60 corresponds to rejection of 50 and 60 Hz ac power mains noise.

Accuracy (does not include sensor or measurement noise):

- 0 to 40 °C: ±(0.04% of measurement + offset)
- –40 to 70 °C: ±(0.06% of measurement + offset)

Voltage Measurement Accuracy Offsets:

	Typical Offset (µV RMS)	
Range (mV)	Differential with Input Reversal	Single-Ended or Differential without Input Reversal
±5000	±0.5	±2
±1000	±0.25	±1
±200	±0.15	±0.5

Measurement Settling Time: 20 µs to 600 ms; 500 µs default

Multiplexed Measurement Time:

Measurement time = INT(multiplexed measurement time • (reps+1) + 2ms

	Differential with Input Reversal	Single-Ended or Differential without Input Reversal
Example fN1[1] (Hz)	Time[2] (ms)	Time[2] (ms)
15000	2.04	1.02
60	35.24	17.62
50	41.9	20.95
5	401.9	200.95

[1] Notch frequency (1/integration time).

[2] Default settling time of 500 µs used.

Resistance measurements specifications

The data logger makes ratiometric-resistance measurements for four- and six-wire full-bridge circuits and two-, three-, and four-wire half-bridge circuits using voltage excitation. Excitation polarity reversal is available to minimize dc error.

Accuracy:

Assumes input reversal for differential measurements `RevDiff` and excitation reversal `RevEx` for excitation voltage <1000 mV. Does not include bridge resistor errors or sensor and measurement noise.

- **0 to 40 °C**: ±(0.01% of voltage measurement + offset)
- **–40 to 70 °C**: ±(0.015% of voltage measurement + offset)
- **–55 to 85 °C (XT)**: ±(0.02% of voltage measurement + offset)

Period-averaging measurement specifications

Terminals: SE terminals 1-16

Accuracy: ±(0.01% of measurement + resolution), where resolution is 0.13 µs divided by the number of cycles to be measured

Ranges:

- Minimum signal centered around specified period average threshold.
- Maximum signal centered around data logger ground.
- Maximum frequency = 1/(2 * (minimum pulse width)) for 50% duty cycle signals

Gain Code Option	Voltage Gain	Minimum Peak to Peak Signal (mV)	Maximum Peak to Peak Signal (V)	Minimum Pulse Width (µs)	Maximum Frequency (kHz)
0	1	500	10	2.5	200
1	2.5	50	2	10	50
2	12.5	10	2	62	8
3	64	2	2	100	5

Current-loop measurement specifications

The data logger makes current-loop measurements by measuring across a current-sense resistor associated with the RS-485 resistive ground terminal.

Terminals: RG1 and RG2

Maximum Input Voltage: ±16 V

Resistance to Ground: 101 Ω

Current Measurement Shunt Resistance: 10 Ω

Maximum Current Measurement Range: ±80 mA

Absolute Maximum Current: ±160 mA

Resolution: ≤ 20 nA

Accuracy: ±(0.1% of reading + 100 nA) @ -40 to 70 °C

Pulse measurement specifications

Two inputs (P1-P2) individually configurable for switch closure, high-frequency pulse, or low-level AC measurements. See also Digital input/output specifications (p. 4). Each terminal has its own independent 32-bit counter.

> NOTE:
> Conflicts can occur when a control port pair is used for different instructions (`TimerInput()`, `PulseCount()`, `SDI12Recorder()`, `WaitDigTrig()`). For example, if C1 is used for `SDI12Recorder()`, C2 cannot be used for `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`.

Maximum Input Voltage: ±20 VDC

Maximum Counts Per Channel: 2^{32}

Maximum Counts Per Scan: 2^{32}

Input Resistance: 5 kΩ

Accuracy: ±(0.02% of reading + 1/scan)

Switch closure input

Terminals: C1-C8

Pull-Up Resistance: 100 kΩ to 5 V

Event: Low (<0.8 V) to High (>2.5 V)

Maximum Input Frequency: 150 Hz

Minimum Switch Closed Time: 5 ms

Minimum Switch Open Time: 6 ms

Maximum Bounce Time: 1 ms open without being counted

High-frequency input

Terminals: C1-C8

Pull-Up Resistance: 100 kΩ to 5 V

Event: Low (<0.8 V) to High (>2.5 V)

Maximum Input Frequency: 250 kHz

Low-level AC input

Minimum Pull-Down Resistance: 10 kΩ to ground

DC-offset rejection: Internal AC coupling eliminates DC-offset voltages up to ±0.05 VDC

Input Hysteresis: 12 mV at 1 Hz

Low-Level AC Pulse Input Ranges:

Sine wave (mV RMS)	Range (Hz)
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

Digital input/output specifications

Terminals configurable for digital input and output (I/O) including status high/low, pulse width modulation, external interrupt, edge timing, switch closure pulse counting, high-frequency pulse counting, UART[1], RS-232[2], RS-485[3], SDM[4], SDI-12[5], I2C[6], and SPI[7] function. Terminals are configurable in pairs for 5 V or 3.3 V logic for some functions.

> NOTE:
> Conflicts can occur when a control port pair is used for different instructions (`TimerInput()`, `PulseCount()`, `SDI12Recorder()`, `WaitDigTrig()`). For example, if C1 is used for `SDI12Recorder()`, C2 cannot be used for `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`.

Terminals: C1-C8

Maximum Input Voltage: ±20 V

Logic Levels and Drive Current:

Terminal Pair Configuration	5 V Source	3.3 V Source
Logic low	≤ 1.5 V	≤ 0.8 V
Logic high	≥ 3.5 V	≥ 2.5 V

Edge timing

Terminals: C1-C8

Maximum Input Frequency: ≤ 1 kHz

---

[1]Universal Asynchronous Receiver/Transmitter for asynchronous serial communications.
[2]Recommended Standard 232. A loose standard defining how two computing devices can communicate with each other. The implementation of RS-232 in Campbell Scientific data loggers to computer communications is quite rigid, but transparent to most users. Features in the data logger that implement RS-232 communication with smart sensors are flexible.
[3]Recommended Standard 485. A standard defining how two computing devices can communicate with each other.
[4]Synchronous Device for Measurement. A processor-based peripheral device or sensor that communicates with the data logger via hardwire over a short distance using a protocol proprietary to Campbell Scientific.
[5]Serial Data Interface at 1200 baud. Communication protocol for transferring data between the data logger and SDI-12 compatible smart sensors.
[6]Inter-Integrated Circuit is a multi-master, multi-slave, packet switched, single-ended, serial computer bus.
[7]Serial Peripheral Interface - a clocked synchronous interface, used for short distance communications, generally between embedded devices.

Resolution: 500 ns

Edge counting

Terminals: C1-C8

Maximum Input Frequency: ≤ 2.3 kHz

Quadrature input

Terminals: C1-C8 can be configured as digital pairs to monitor the two sensing channels of an encoder.

Maximum Frequency: 2.5 kHz

Resolution: 31.25 µs or 32 kHz

Pulse-width modulation

Maximum Period: 36.4 seconds

Resolution:

- **0 – 5 ms**: 83.33 ns
- **5 – 325 ms**: 5.33 µs
- **> 325 ms**: 31.25 µs

Communications specifications

Ethernet Port: RJ45 jack, 10/100Base Mbps, full and half duplex, Auto-MDIX, magnetic isolation, and TVS surge protection.

Internet Protocols: Ethernet, PPP, RNDIS, ICMP/Ping, Auto-IP (APIPA), IPv4, IPv6, UDP, TCP, TLS, DNS, DHCP, SLAAC, Telnet, HTTP(S), FTP(S), POP3/TLS, NTP, SMTP/TLS, SNMPv3, CS I/O IP

Additional Protocols: CPI, PakBus, PakBus Encryption, SDM, SDI-12, Modbus RTU / ASCII / TCP, DNP3, custom user definable over serial, UDP, NTCIP, NMEA 0183, I2C, SPI

USB Device: Micro-B device for computer connectivity

CS I/O: 9-pin D-sub connector to interface with Campbell Scientific CS I/O peripherals.

SDI-12 (C1, C3, C5, C7): Four independent SDI-12 compliant terminals are individually configured and meet SDI-12 Standard v 1.4.

RS-232/CPI: Single RJ45 module port that can operate in one of two modes: CPI or RS-232. CPI interfaces with Campbell Scientific CDM measurement peripherals and sensors. RS-232 connects, with an adapter cable, to computer, sensor, or communications devices serially.

CPI: One CPI bus. Up to 1 Mbps data rate. Synchronization of devices to 5 µS. Total cable length up to 610 m (2000 ft). Up to 20 devices. CPI is a proprietary interface for communications between Campbell Scientific data loggers and Campbell Scientific CDM peripheral devices. It consists of a physical layer definition and a data protocol.

Hardwired: Multi-drop, short haul, RS-232, fiber optic

Satellite: GOES, Argos, Inmarsat Hughes, Irridium

Standards compliance specifications

View EU Declarations of Conformity at www.campbellsci.com/cr1000x.

Shock and Vibration: MIL-STD 810G methods 516.6 and 514.6

EMI and ESD protection:

- **Immunity**: Meets or exceeds following standards:
  - **ESD**: per IEC 61000-4-2; ±15 kV air, ±8 kV contact discharge
  - **Radiated RF**: per IEC 61000-4-3; 10 V/m, 80-1000 MHz
  - **EFT**: per IEC 61000-4-4; 4 kV power, 4 kV I/O
  - **Surge**: per IEC 61000-4-5; 4 kV power, 4kV I/O
  - **Conducted RF**: per IEC 61000-4-6; 10 V power, 10 V I/O
- Emissions and immunity performance criteria available on request.

Warranty

Standard: Three years against defects in materials and workmanship.

Extended (optional): An additional four years. against defects in materials and workmanship, bringing the total to 7 years.